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**REVIEW OF THE TORTUGAS PINK
SHRIMP FISHERY FROM MAY
1987 TO JANUARY 1989**

BY

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INTRODUCTION

The Gulf of Mexico Shrimp Fishery Management Plan established an area commonly known as the Tortugas Shrimp Sanctuary off south Florida in May 1981 (Fig. 1). The goal of the Gulf of Mexico Fishery Management Council in establishing this no shrimping zone was to avoid the removal of small shrimp, with the objective of increasing yield from the fishery. This decision was based on scientific evidence that showed the Sanctuary area to be the nursery ground for the Tortugas stock of the pink shrimp Penaeus duorarum, and that the yield of offshore pink shrimp would be greater if harvest was delayed until shrimp were larger than minimum legal size in Florida (69 tails per pound) (Linder, 1965; Berry, 1970). Since May 1981, the whole Sanctuary has been closed to trawling, with the exception of a small region locally known as the "toe area", which has been reopened during two brief periods. The purpose of the initial opening (April 1983 through August 1984) was to evaluate the effects of trawling in this area (Klima and Patella, 1986). The recent opening (November 1988 through January 1989) allowed fishermen more access to a reduced pink shrimp stock (Nance and Patella, 1988).

This paper reviews the characteristics of the Tortugas fishery from May 1987 to January 1989 (biological year 1987 and part of 1988) and compares results with historical data. Deviations from historical averages are discussed in light of the established Sanctuary. Current trends with regards to the Tortugas fishery also are discussed.

METHODS

Fishery Data Statistics

Collections of detailed catch statistics describing the Gulf of Mexico shrimp fishery in United States waters since 1956 are compiled by and available from the Southeast Fisheries Center (SEFC/Office of Economics and Statistics-ESO). The procedures used to collect them have been described by Klima (1980). These statistics consist of catch, recorded as pounds of shrimp (head-off); fishing effort, recorded as either 24 hours of actual fishing time or number of trips; and size composition of catch, expressed in eight "count" or size categories representing number of shrimp tails per pound (<15, 15-20, 21-25, 26-30, 31-40, 41-50, 51-67 and ≥ 68).

These statistics were grouped and analyzed by biological year (May through April) and used in this report to determine the effects of the Tortugas Shrimp Sanctuary on the fishery. These statistics were also used to calculate other useful values such as catch per unit effort (CPUE), expressed as pounds per 24 hours of actual fishing, and average number of shrimp per pound. All

statistical tests utilized in the report are described in detail by Nance et al. (1986).

Pink shrimp recruitment from 1960-1988 for the entire eastern Gulf of Mexico (statistical subareas 1-9) was estimated using VPA analysis (Nance and Nichols, 1988).

RESULTS

Landings

Annual landings during pre-closure biological years (1960-1980) in statistical subareas 1 through 3, have averaged approximately 9.98 million pounds (Fig. 2). Pounds landed have fluctuated from a high of 13.4 million pounds in 1960 to a low of 8.0 million pounds in 1971. Yet, even with this 5.4 million pound range, the fishery has remained relatively stable throughout this 21 year period. The standard deviation around the historical mean was only ± 1.69 million pounds, with a value of 17% for the coefficient of variation. Only during biological years 1960, 1965 and 1971 have yearly landings fallen outside one standard deviation of the mean (two values above the mean and one value below).

The annual landings for the post-closure period (1981-1987) have averaged 8.06 million pounds, with a standard deviation of ± 1.95 million pounds. No significant difference was statistically determined to exist between the pre-closure and post-closure periods, even though a decreasing trend in catch is visible from the late 1970's to present. During biological year 1986 (May 86-April 87), only 5.5 million pounds of pink shrimp were landed from statistical subareas 1-3 (Fig. 2). This value represented the lowest catch recorded from the area and was the first year that was significantly below the historical average (Nance and Patella, 1988).

Pink shrimp landings during biological year 1987 are also low in comparison to the historical average and all years since 1960, with the exception of 1986. Landings for 1987 (May 1987 - April 1988) were around 7.0 million pounds. This value is low, but is not significantly below the historical average.

Estimates of pink shrimp landings during biological year 1988 are low, with only 6.0 to 6.5 million pounds expected from the area. This value level, if it occurred, would be significantly below the historical average. Only actual landings from May 1988-January 1989 are available for analysis, but tentative figures from February 1989-April 1989 were gathered from port agents in the area. Only landings were estimated, so statistics such as effort, CPUE, and size composition will only be reported for the first nine months of biological year 1988.

The monthly pattern of shrimp landings in biological years 1987 and 1988 were compared with historical monthly averages. This comparison documented a dramatic decrease in pounds landed (Fig. 3). Even though all months except four were below average, only two months were significantly below their respective historical average. The significantly below average months occurred in the early winter months (October-November) in biological year 1988. In biological year 1987 the shrimp seemed to be present on the grounds in the early winter, but at a level that was quickly reduced by fishing. In biological year 1988 the shrimp were late in arriving onto the fishing grounds and when they did arrive they were in greatly reduced numbers.

Fishing Effort

Fishing effort by biological year, May 1960 to April 1986, in statistical subareas 1 through 3 has averaged 15,900 days per year with a standard deviation of $\pm 2,400$ days per year (Fig. 4). The coefficient of variation was 15%. The small standard deviation and low coefficient of variation are good indicators of the stability of this fishery. Even so, effort has fluctuated from a high of 22,000 days expended in 1960 to a low of only 11,000 days fished in 1979.

Fishing effort reported for biological year 1987 was around 13,900 days, which is below average, but still within one standard deviation of the historical mean. Only four years, 1976, 1979, 1981 and 1985 have been below the one standard deviation from the mean level.

The monthly pattern of fishing effort in biological year 1987 and the first 9 months of biological year 1988 were compared with historical monthly averages (Fig. 5). Below average fishing effort values were noted during most of the months of biological years 1987 and 1988. Only the fall months of biological year 1987 (August-October) and June in 1988 had above average effort value. No values were significantly different than their historical counterpart. Effort data is not yet available for the February 1989-April 1989 period, but since reported catches were below average during this period it is also assumed that effort levels dropped below their historical values.

Catch per Unit Effort

Catch per unit effort (CPUE), is reported as pounds caught during a 24 hour fishing day (pounds per day). The annual CPUE at the Tortugas fishing grounds has been a very stable parameter over the past 27 years. CPUE values have averaged about 604 pounds per day with a standard deviation of around 91 pounds per day (Fig. 7). This has resulted in a coefficient of variation value of only 15%. The highest historical CPUE recorded was close to 800 pounds per day during biological year

1981 and the lowest CPUE was 436 pounds per day, which occurred during biological year 1986. The annual CPUE value during biological year 1987 was below average at only 507 pounds per day. This value is one of the lowest CPUE values ever recorded from this fishery, but it was not significantly different from the historical mean.

Even though annual CPUE values for the past 27 years have not varied considerably (with the exception of 1986), large variations have been noted in monthly CPUE values (Nance and Patella, 1987). Thus, a large standard deviation value is found around each monthly historical mean CPUE value. Monthly CPUE values for biological year 1988 were each compared with their respective monthly historical mean value (Fig. 7). All months, except June 1987, May 1988, June 1988 and December 1988 had below average CPUE values when compared with their historical average. This was expected, since landings were below average during the period, while effort levels were near historical levels.

In comparing the monthly CPUE values with the historical data, we also plotted a ratio of the present monthly CPUE values from May 1981 through January 1989 over the historical monthly CPUE values (Fig. 8). These values indicated for the 3 months of greatest catch (December, January and February) that the biological year 1987 winter values (December 1987-February 1988) were very similar to winter values in biological years 1982, 1983 and 1986, but were below winter values in biological years 1981, 1984 and 1985. Biological year 1988 winter values appear intermediate between the two data sets, with a high value in December, but a low value in January and probably February.

Biological year 1986 (May 1986-April 1987) was set apart from all other years by the fact that all months, except one, were below the equality line (Fig. 8). Similar results were seen for biological year 1987 (May 1987-April 1988), with only 3 months above the equality line. Biological year 1988 should be comparable to 1987 with 3 or less months above the equality line.

Recruitment

Total pink shrimp recruitment (statistical subareas 1-9) has been quite stable over the past 27 years, with a mean value of 1.6 billion shrimp. Recruitment has ranged from a high of 2.5 billion shrimp experienced in biological year 1980 to a low of 1.2 billion shrimp in biological year 1986. The total pink shrimp recruitment for the entire eastern Gulf during a given biological year is highly correlated (0.93) to total eastern Gulf pink shrimp catch during the same period. Regression analysis, with catch as the dependent variable and recruitment as the independent variable, gave an r-squared value of 0.86. Thus, as one would expect, the amount of catch experienced from the eastern Gulf pink shrimp fishery in a given year, is a direct

result of the strength of the eastern Gulf recruitment of pink shrimp during the same period. If recruitment is low, catch will be low. If recruitment is high, catch will be high.

Recruitment of pink shrimp onto the Tortugas grounds usually occurs during two periods in a biological year. Fall recruitment is measured from July through December, with the peak of the season from August through October. The spring season is measured from January through June, with peak recruitment usually from March through May. Fall recruitment for the entire eastern Gulf has averaged 820 million shrimp since 1960, while spring recruitment has average 790 million shrimp. Both periods have experienced below average recruitment since the spring of 1986.

Pink shrimp catch on the Tortugas grounds for a given biological year has a high correlation to fall season recruitment (0.72), but a low correlation to eastern Gulf spring season recruitment (0.21). Regression analysis conducted with Tortugas catch and eastern Gulf fall recruitment gave a r-squared value of 0.59 (Fig. 9).

Biological year 1986 had both the lowest total recruitment (1.16 billion shrimp) and the lowest fall recruitment (.520 billion shrimp) on record for the eastern Gulf. Thus, it is not surprising that this year also had the lowest annual Tortugas catch ever recorded. Fall recruitment for the eastern Gulf during biological year 1987 (July 87-December 1987) was only .640 billion shrimp.

Size

The size of shrimp landed may be used to identify change that may have occurred due to fishing. If the management measure of prohibiting trawling in the sanctuary was effective and restricted the capture of small shrimp, one would expect the size of shrimp to increase and therefore be different than the historical average. Many small shrimp were caught when part of the Tortugas Sanctuary (the toe area) was opened to fishing for comparative purposes from April 1983 through August 1984, (Table 1). Once this area was closed again, mean number of shrimp per pound decreased abruptly. Thus, small shrimp (50-60 count) were caught in great abundance during that open period, while larger sized shrimp (35-45 count) were caught thereafter with the exception of the 1987 season (Fig. 10). During the entire calendar year of 1987, except July and August, smaller than average shrimp were landed from the fishery. This trend continued into the 1988 season, but larger shrimp began to be caught after the July 1988 period. The "toe area" was opened this last season from November 1988 through January 1989, but only smaller than average shrimp were caught during December 1988 (Fig. 10).

DISCUSSION

In general the Tortugas fishery has been quite stable over the last 28 year period (1960-1987). Evaluation of annual historical data showed very low coefficient of variation values for landings (17%), fishing effort (15%), and CPUE (15%). The shrimping grounds are bounded by a bottom of loggerhead sponges and coral reefs where pink shrimp are protected from trawling. This area of untrawable bottom surrounding the fishing grounds may be one reason why this fishery has been so stable since 1960.

Even with this noted stability a reduction in catch and CPUE has been graphically noticed since the late 1970's with the exclusion of 1980, 1984 and 1985 (Fig. 2). Biological year 1986 was the lowest year on record. Biological year 1987 was also below average, but was better than 1986. Even though no significant differences were found when mean values from pre-closure biological years (1960-1980) were statistically compared to mean values from post-closure biological years (1981-1987), there appears to be a declining trend in catch from the Tortugas grounds since the late 1970's. The trend noted in landings from the Tortugas fishery is very similar to landings from the west coast of Florida as a whole (Fig. 11).

During biological year 1987, all fishery indices (pounds landed, effort and CPUE) were below their respective historical averages. Pounds of shrimp were only 7.0 million pounds, with a fishing effort value of about 13,900 days. This computed to an extremely low CPUE value of only 507 pounds per fishing day. None of the values were significantly different than their historical averages.

The offshore pink shrimp fishery discussed thus far is directly dependent on young shrimp migrating in large numbers from nursery areas onto the fishing grounds. If these small shrimp are caught early, maximum yield in the fishery is not attained (Nance and Nichols, 1988). Yet, if recruitment is depressed, landings will also be depressed, since the Sanctuary can only maximize the yield of the shrimp that are available to the fishery. Of the two recruitment intervals, the fall recruitment period seems to be the one that is best correlated to annual catch on the Tortugas grounds. When eastern Gulf fall recruitment is above average, annual Tortugas catch is also usually above average and when fall recruitment is low, annual catch is usually lower than average. Between 1980 and 1987, fall recruitment for the eastern Gulf showed a downward slope with the exceptions of 1984 and 1985 (Nance and Patella, 1988). Thus, the lower than average landings on the Tortugas grounds during most of that eight year period seem to be related to a failure of recruitment of pink shrimp from nursery areas. In 1986 the eastern Gulf recruitment in both the fall and spring periods was below average. In 1987 recruitment was still depressed, but not

to the extent it was during the 1986 biological year. Periods of low recruitment were also observed in the late 1960's and early 1970's (Fig. 12). Thus, this present condition is not the first time low recruitment has been observed in the fishery.

In some fisheries, recruitment over-fishing is a major cause of the reduced recruitment condition. Yet, there was no apparent established link between pink shrimp parent stocks and recruitment in the stock assessment analysis (Nance and Nichols, 1988). Thus, recruitment over-fishing does not appear to be a likely candidate for the cause of the drop in recruitment.

The permanent closure of the Tortugas Sanctuary was established in May 1981 to prevent the capture of small shrimp. As stated earlier, the whole sanctuary has been closed to trawling since that time, with two exceptions. The "toe area" was opened to trawling from April 1983 through August 1984 and again from November 1988 through January 1989 to evaluate the effects. A report by Klima and Patella (1986) showed an increase in number of small shrimp caught during the entire initial period the "toe area" was opened. With the reclosure of the entire Sanctuary to shrimping activities in August 1984, size ratio values (average monthly size divided by historical monthly size) again decreased. During the first opened period, small shrimp being recruited to the offshore fishery were rapidly harvested when the "toe area" was opened, but small shrimp were able to increase in size and then enter the fishery when the "toe area" was closed (Table 1).

Beginning in January 1987, smaller than average shrimp have been landed from the fishery even when the entire Sanctuary was closed. It must be assumed that these smaller than average sized shrimp were obtained from the fishing grounds and not from vessels fishing inside the Sanctuary, since violations in the closed area were at very low levels during the 1987 season (NMFS Enforcement Division)¹. Shrimp distribution patterns may have shifted during 1987 in response to environmental changes (e.g., reduced rainfall, higher water temperature, hurricane Floyd, etc.), but we have no data to support this theory.

Smaller than average sized shrimp continued to be caught into the 1988 season, but the trend shifted in July 1988 when larger than average shrimp again appear to be more abundant on the fishing grounds. Even when the toe area was again opened to fishing for a brief 3 month period, smaller than average shrimp were caught only in December 1988.

The major objectives of the Tortugas Sanctuary are to 1)

¹Personal communication, Southeast Regional Office, Law Enforcement Group, 9450 Koger Blvd., St. Petersburg, FL 33702.

eliminate discarding of undersized shrimp, and 2) increase the yield per recruit. We have no data to support or reject discarding of undersized shrimp. Since catch rates were so low this year, it is assumed that most shrimp caught, no matter the size, were landed. This may account for the increase in smaller than average sized shrimp being landed during the 1987 season.

Yield per recruit was enhanced with the presence of the Tortugas Sanctuary, since it prevents fishing on shrimp as they migrate from the nursery areas to the offshore fishing grounds. Yet, yield obtained for each recruit during biological year 1987 was lower than it might have been because of the small size of the shrimp landed. It is not known why these shrimp were available on the grounds in 1987, but the trend seems to have shifted back to normal after July 1988. This declining trend in catch seems to have begun in the late 1970's.

SUMMARY

1. Commercial pink shrimp landings from the Tortugas fishery (statistical subareas 1 through 3) have been relatively stable for the past 27 years (1960-1986). Average catch has been 9.6 million pounds per year with a standard deviation of ± 1.9 million pounds per year. Yet, pink shrimp landings during biological year 1987 were only about 7.0 million pounds. It is projected that landings will only be around 6.5 million pounds during biological year 1988. This declining trend in catch seems to have begun in the late 1970's.
2. Fishing effort for pink shrimp on the Tortugas grounds have averaged 15,900 days annually for the past 27 years with a standard deviation of ± 2400 days. During biological year 1987, 13,900 days of fishing were expended on the Tortugas fishery. This is below the historical average, but not significantly different.
3. CPUE (pounds per day fishing) has been the most stable parameter over the 27 year period, from 1960-1986, at the Tortugas fishing area. The historical average has been around 604 pounds per day with a standard deviation of only ± 91 pounds per day. However, the CPUE value for biological year 1987 was only 507 pounds per day. This value is low, but not significantly different than the historical mean. Biological year 1988 values also appear below the historical average for the area.
4. Recruitment of small pink shrimp from the nursery areas onto the grounds was very low for biological year 1986 and again for 1987 for the eastern Gulf of Mexico. It is this reduction in available shrimp that has reduced the catch from the Tortugas fishery. Yet, periods of low recruitment were also observed in the late 1960's and early 1970's, so this present condition is not the first time low recruitment has been observed in the fishery.
5. Larger than average shrimp were landed from the Tortugas grounds during the early part of biological year 1986 (May 1986-December 1986), but smaller than average shrimp have been taken for most months since January 1987. This trend continued until July 1988 when larger than average shrimp again began to be taken from the fishing grounds.
6. The opening of the toe area to fishing for the three month period in biological year 1988 did not increase CPUE and no real change was noted in size of shrimp taken from the grounds.
7. The major objectives of the Tortugas closure are to 1)

eliminate discarding of undersized shrimp, and 2) increase the yield per recruit. We have no data to support or reject discarding of undersized shrimp. Since catch rates are low this year, it is assumed that most shrimp caught, no matter the size, were landed this year. This may account for the increase in smaller than average sized shrimp being landed this past year (January 1987-present).

Yield per recruit was enhanced with the presence of the Tortugas Sanctuary, since it prevents fishing on shrimp as they migrate from the nursery areas to the offshore fishing grounds. Yet, yield obtained for each recruit during the 1987 season was certainly lower because of the small size of the shrimp landed. It is not known why these shrimp were available on the grounds in 1987, but the trend seems to have shifted back to normal after July 1988.

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Table 1. Monthly average weighted number of pink shrimp per pound for 1960-79, 1981, 1982, 1983, 1984, 1985, 1987, and 1988 (+ indicates larger size group and - indicates smaller size group than historical average; bracketed portion indicates open fishing in toe of the boot).

Months	1960-1979		1981	1982	1983
	Average Number/lb	Standard Deviation	Average Number/lb	Average Number/lb	Average Number/lb
May	46.8	5.1	57.4 +	48.4 +	56.8 +
June	45.2	4.5	52.7 +	45.7 +	50.2 +
July	44.0	4.7	44.2 +	36.6 -	58.0 +
August	44.0	7.7	38.9 -	55.0 +	49.6 +
September	48.7	7.9	47.5 -	49.0 +	44.2 -
October	47.9	4.8	41.4 -	43.3 -	44.0 -
November	43.1	3.3	36.4 -	41.3 -	36.6 -
December	40.2	2.8	34.9 -	39.3 -	36.1 -
January	40.2	3.1	35.6 -	43.6 +	49.4 +
February	42.7	3.1	42.1 -	48.0 +	48.1 +
March	47.5	4.4	46.8 -	57.5 +	58.7 +
April	48.3	5.8	49.8 +	54.1 +	60.5 +

Months	1984	1985	1986	1987	1988
	Average Number/lb	Average Number/lb	Average Number/lb	Average Number/lb	Average Number/lb
May	55.9 +	42.4 -	38.9 -	49.4 +	54.5 +
June	53.1 +	42.1 -	45.3 +	56.8 +	49.4 +
July	55.0 +	42.1 -	42.0 -	43.1 -	43.8 -
August	46.9 +	33.5 -	39.4 -	40.1 -	33.6 -
September	36.9 -	55.3 +	40.2 -	51.2 +	32.6 -
October	45.8 -	45.9 -	38.9 -	54.4 +	35.8 -
November	41.0 -	33.0 -	43.0 -	45.4 +	40.9 -
December	35.2 -	35.6 -	39.0 -	41.8 +	44.2 +
January	38.0 -	37.3 -	42.9 +	52.6 +	37.9 -
February	39.8 -	40.1 -	46.3 +	51.6 +	
March	40.5 -	51.1 +	54.5 +	54.8 +	
April	44.2 -	48.4 +	55.6 +	53.8 +	

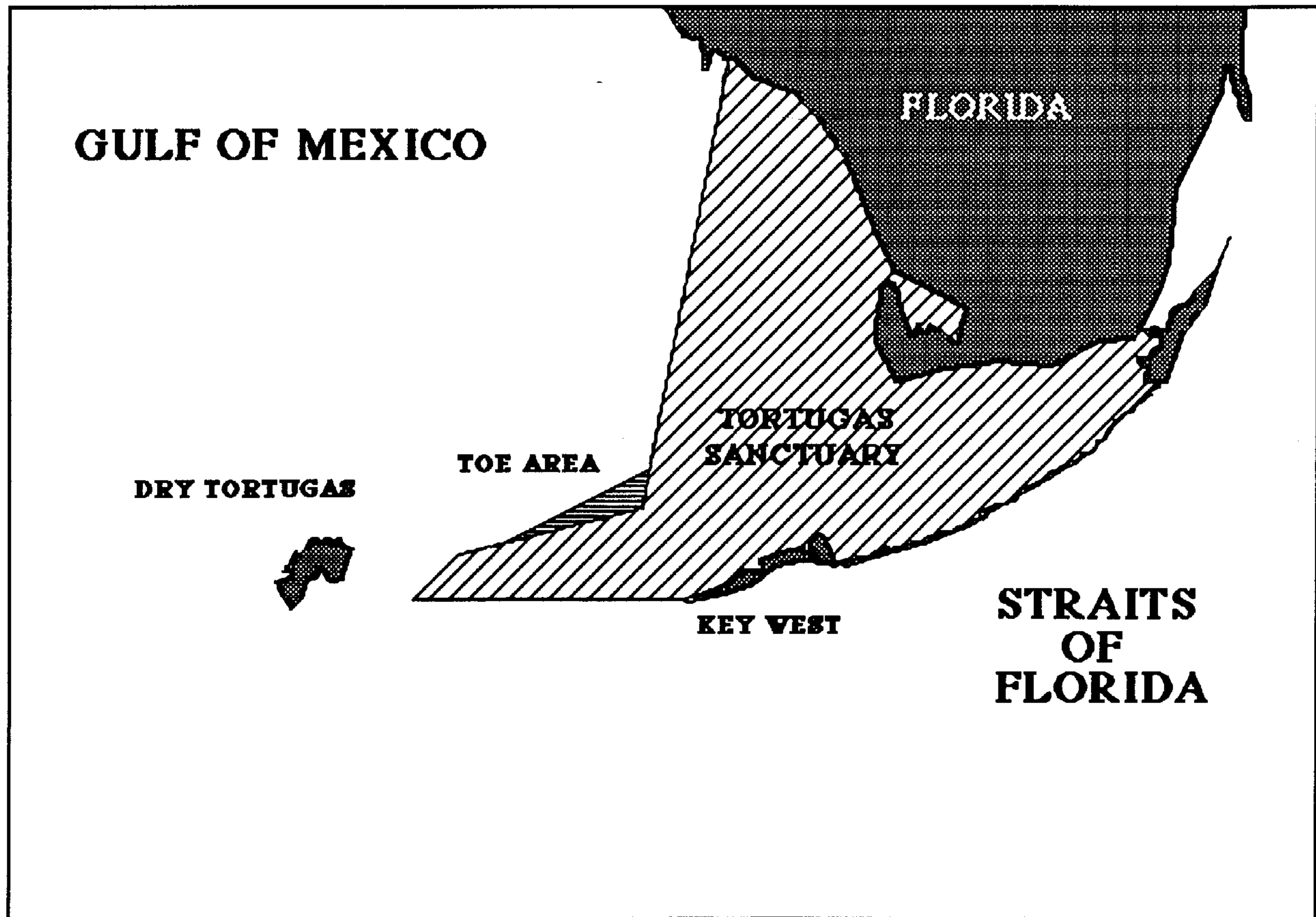


Figure 1. Map of the Tortugas pink shrimp sanctuary off the coast of Florida.

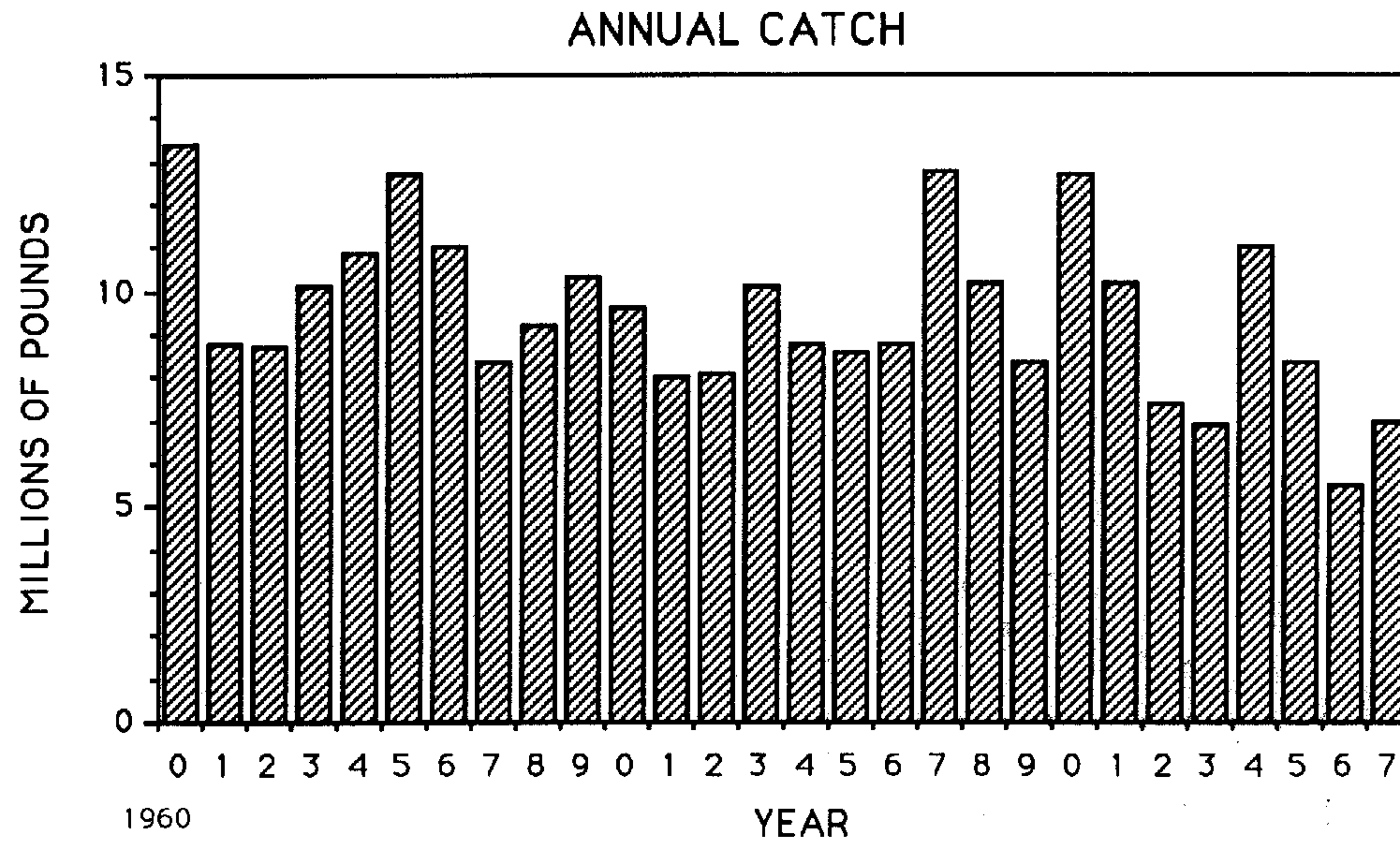


Figure 2. Annual pink shrimp landings from the Tortugas grounds for biological years 1960 through 1987.

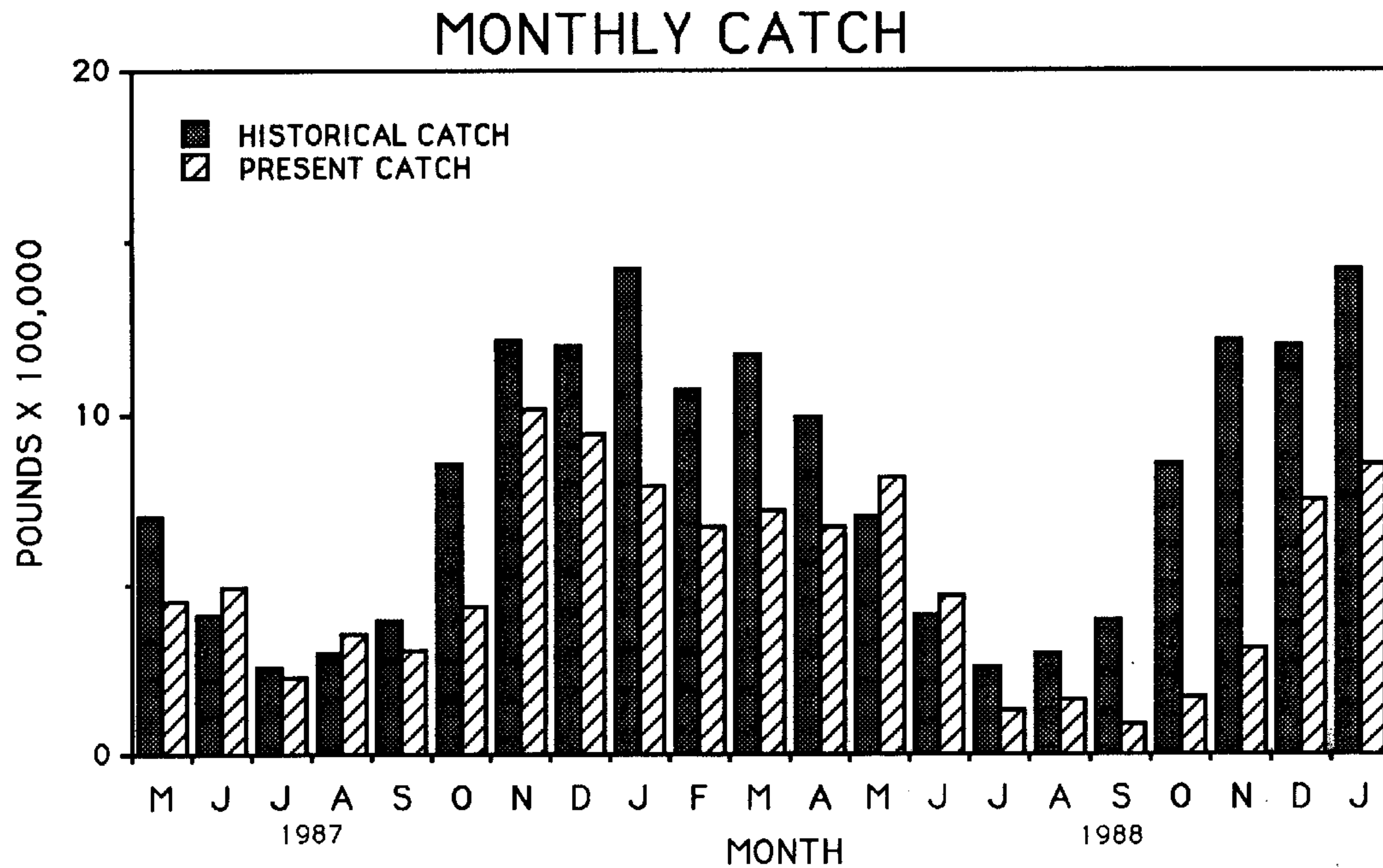


Figure 3. Average monthly historical catch compared to the catch from May 1987 through January 1989 taken on the Tortugas grounds.

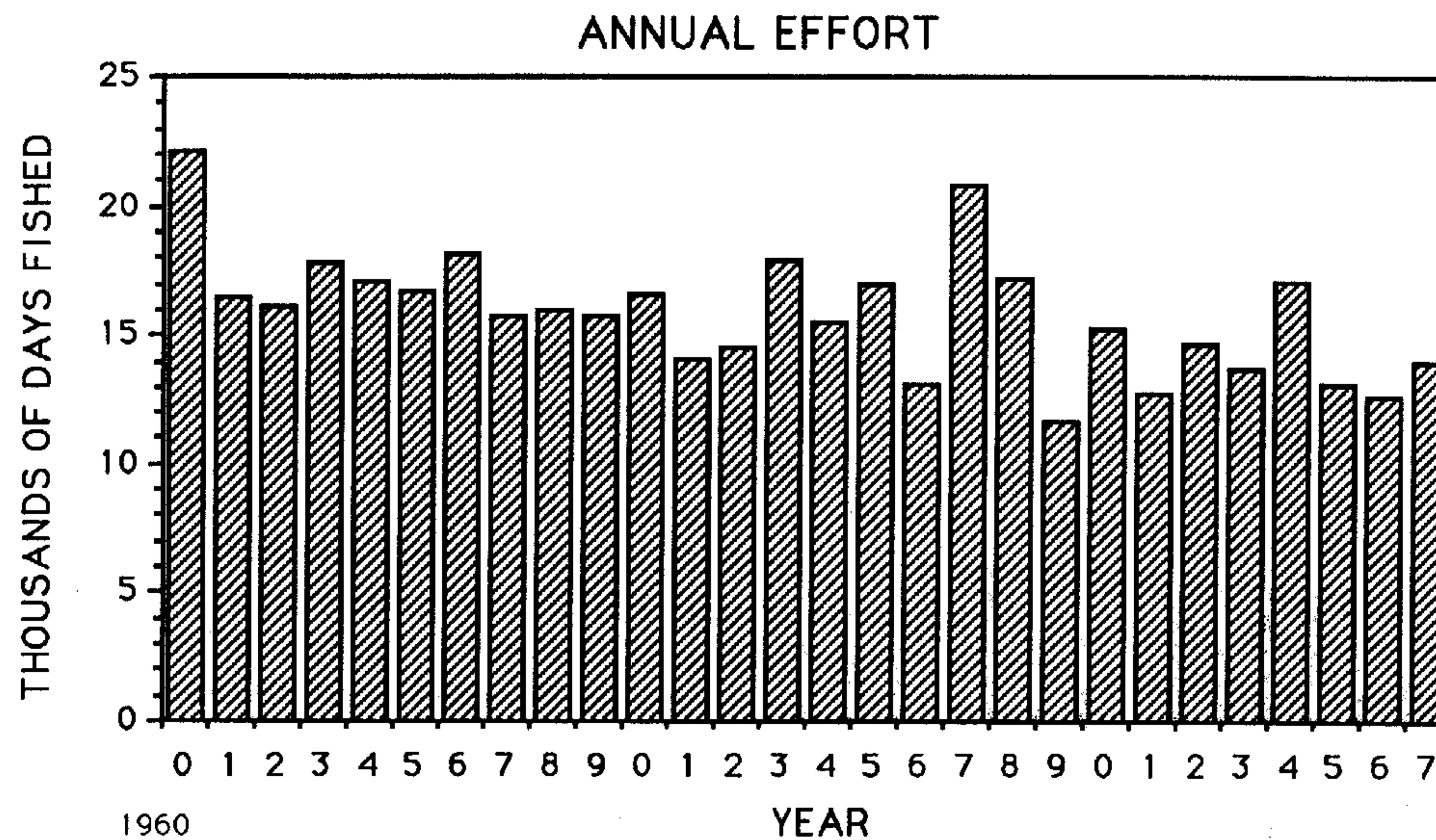


Figure 4. Pink shrimp fishery effort on the Tortugas grounds for biological years 1960 through 1987.

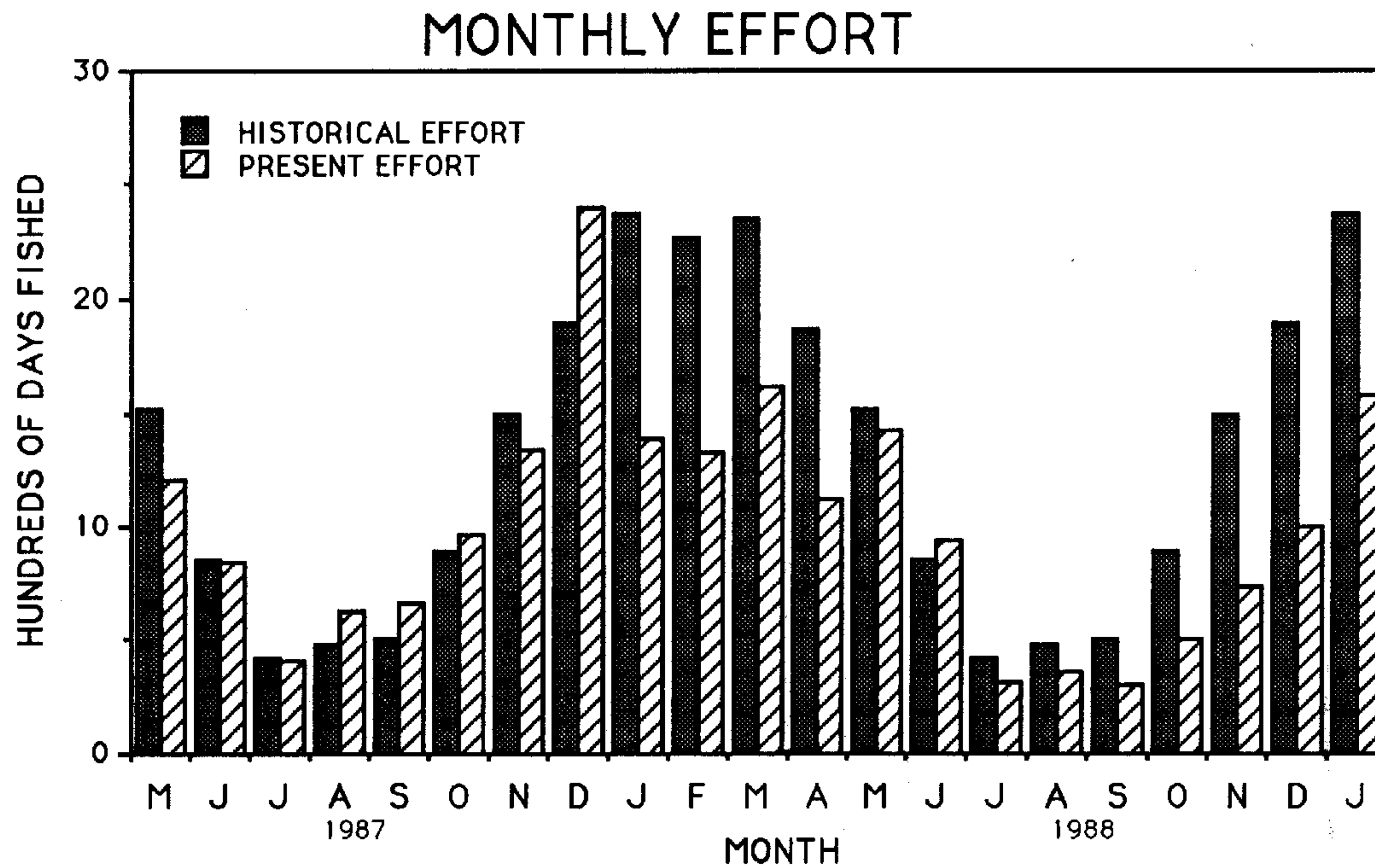


Figure 5. Average monthly historical effort compared to the monthly efforts for May 1987 through January 1989 from the Tortugas grounds.

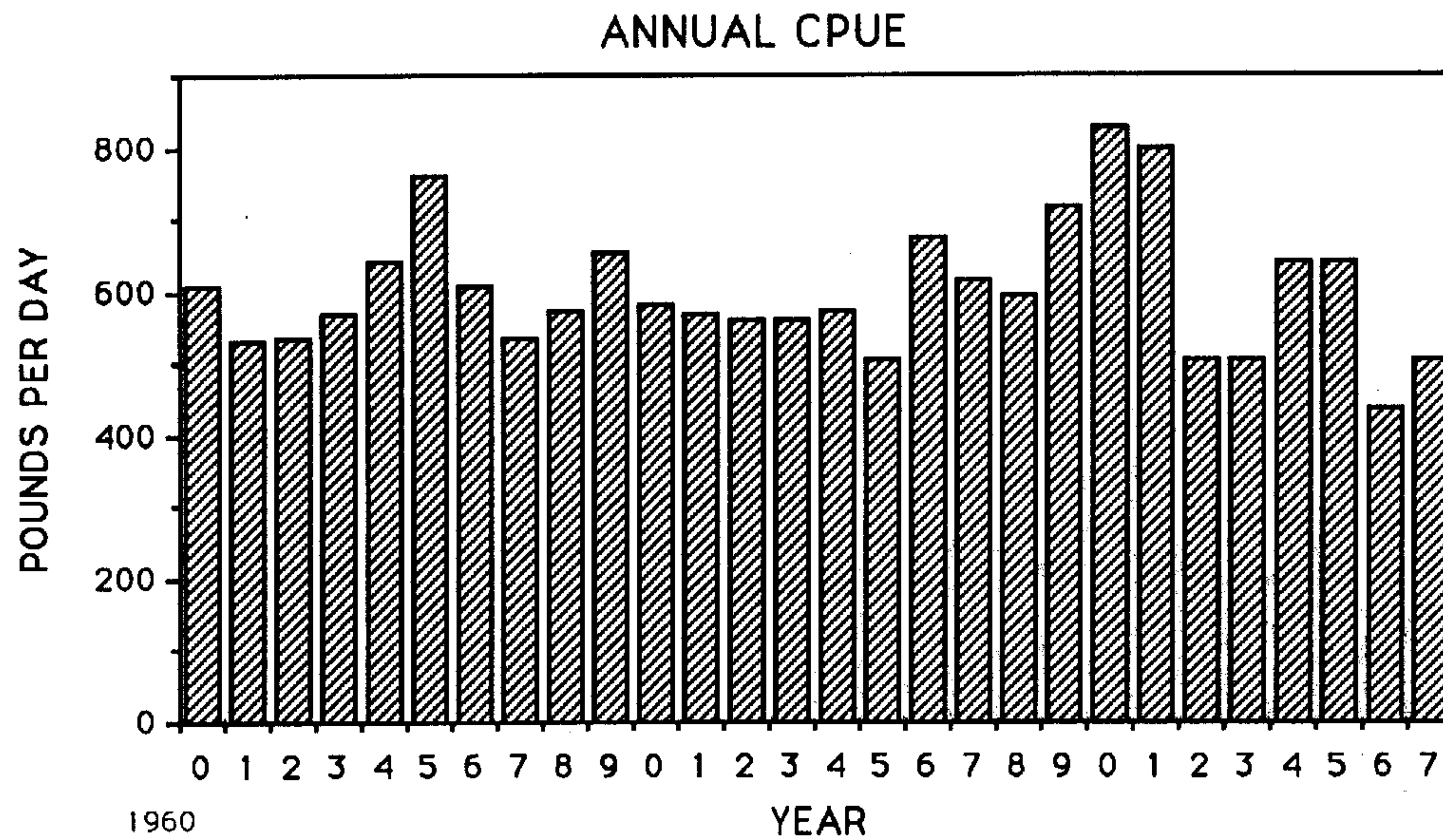


Figure 6. Catch per unit effort (CPUE) for biological years 1960 through 1987.

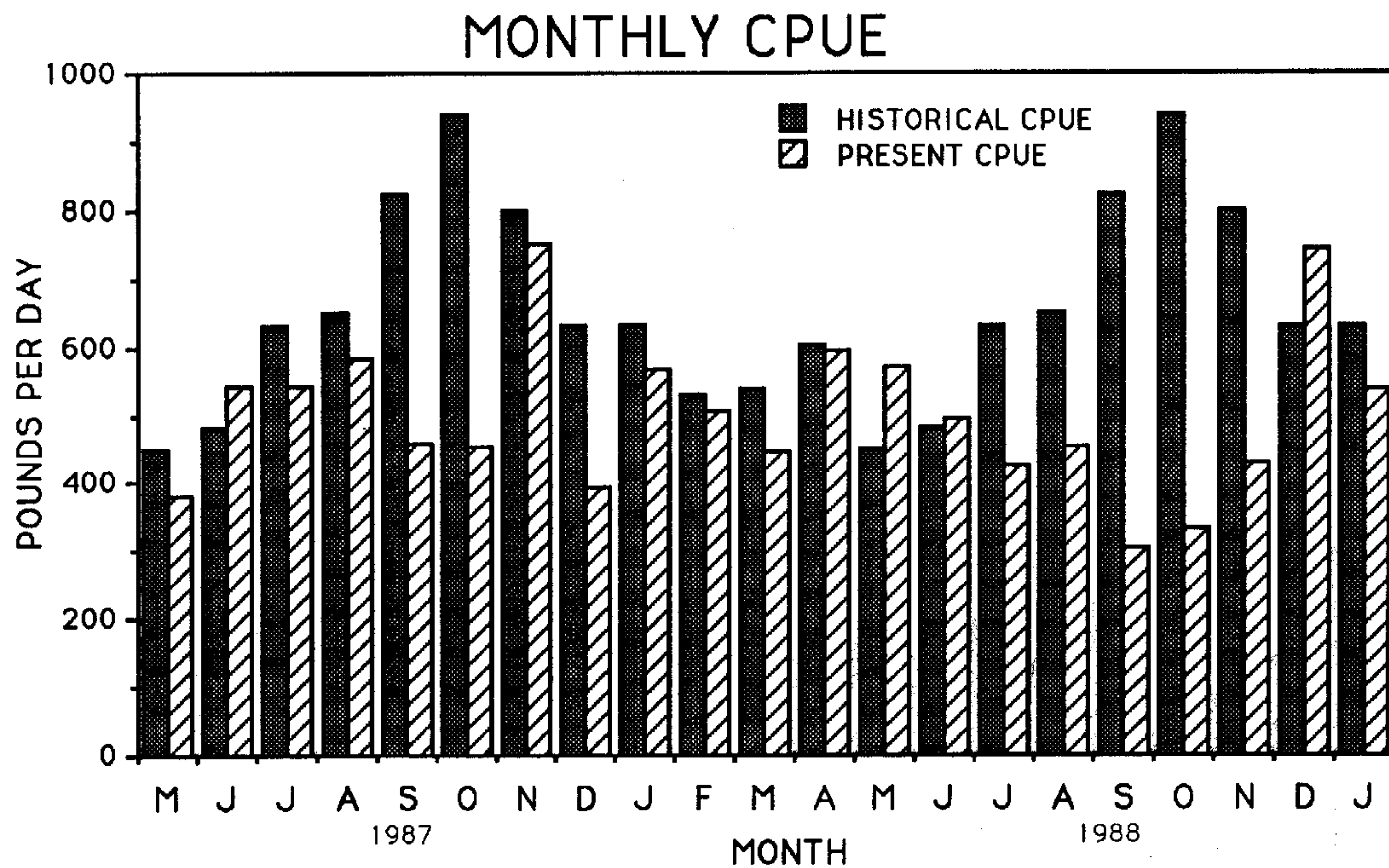


Figure 7. Average monthly historical CPUE values compared to the monthly CPUE values for May 1987 through January 1989 from the Tortugas grounds.

CPUE RATIO ANALYSIS

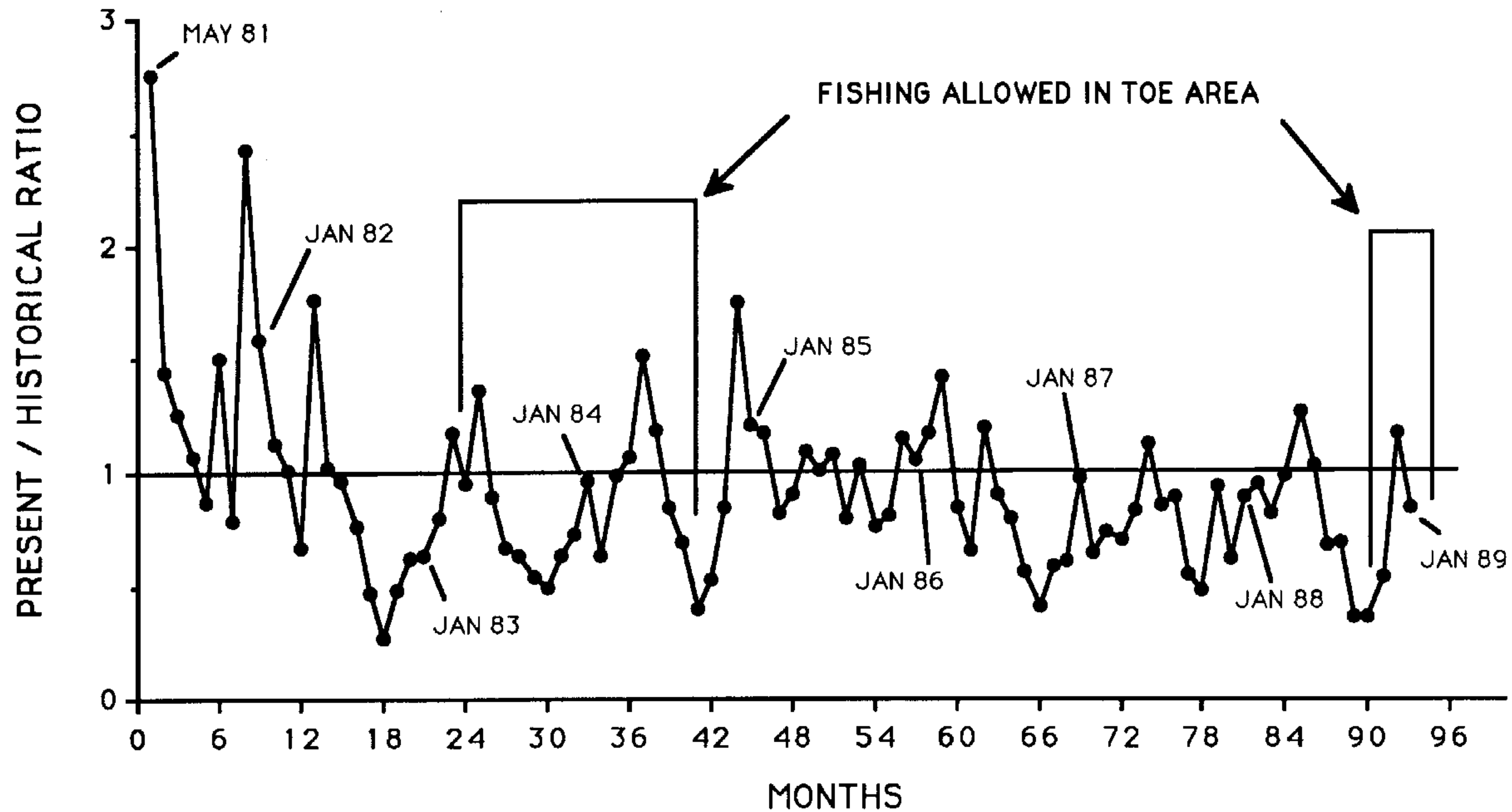


Figure 8. Ratios of monthly CPUE from May 1981 through January 1989 compared with monthly historical CPUE values (1960 through 1979).

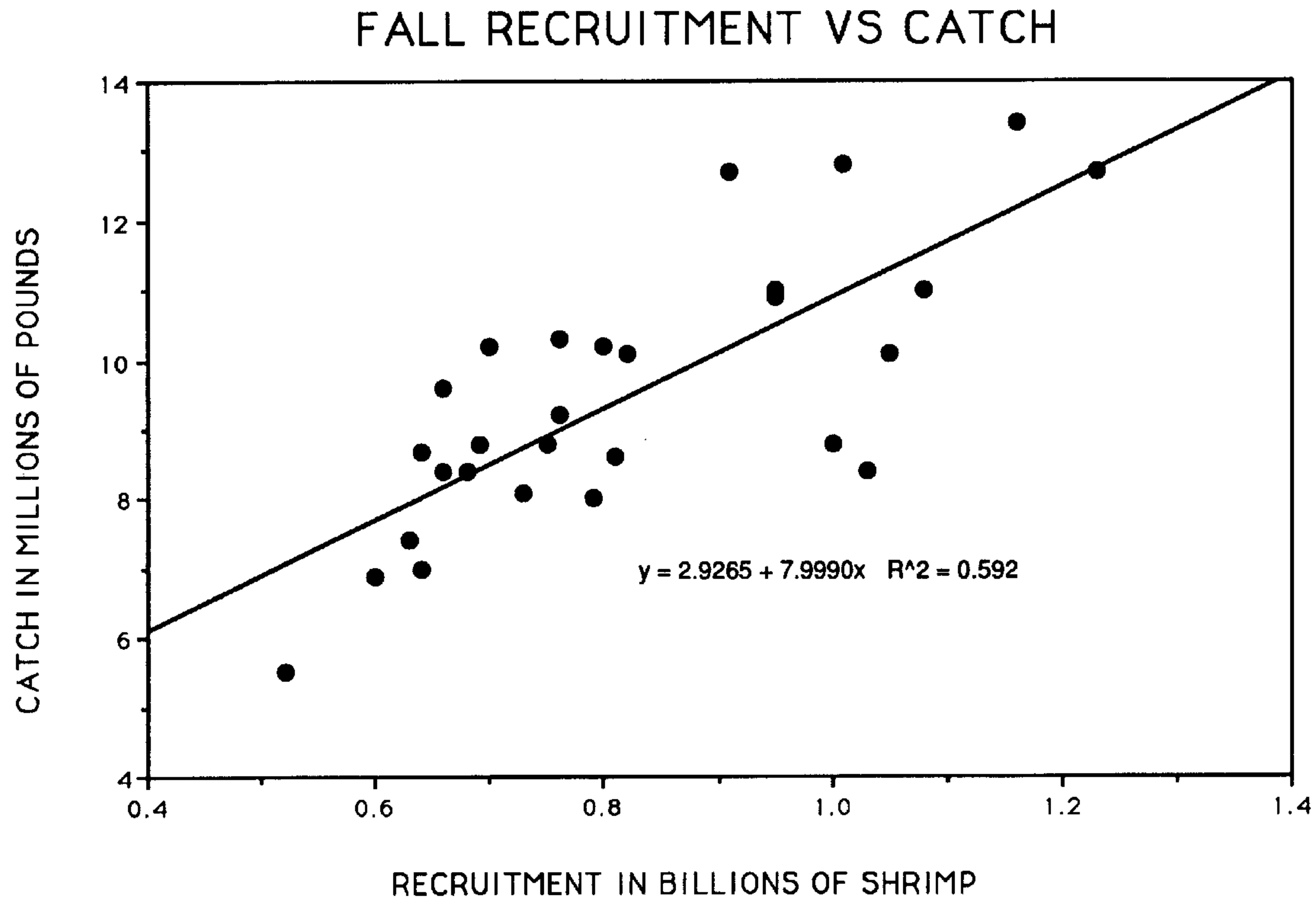


Figure 9. Regression analysis of eastern Gulf of Mexico fall recruitment estimates and biological year catch from the Tortugas fishing grounds.

SIZE RATIO ANALYSIS

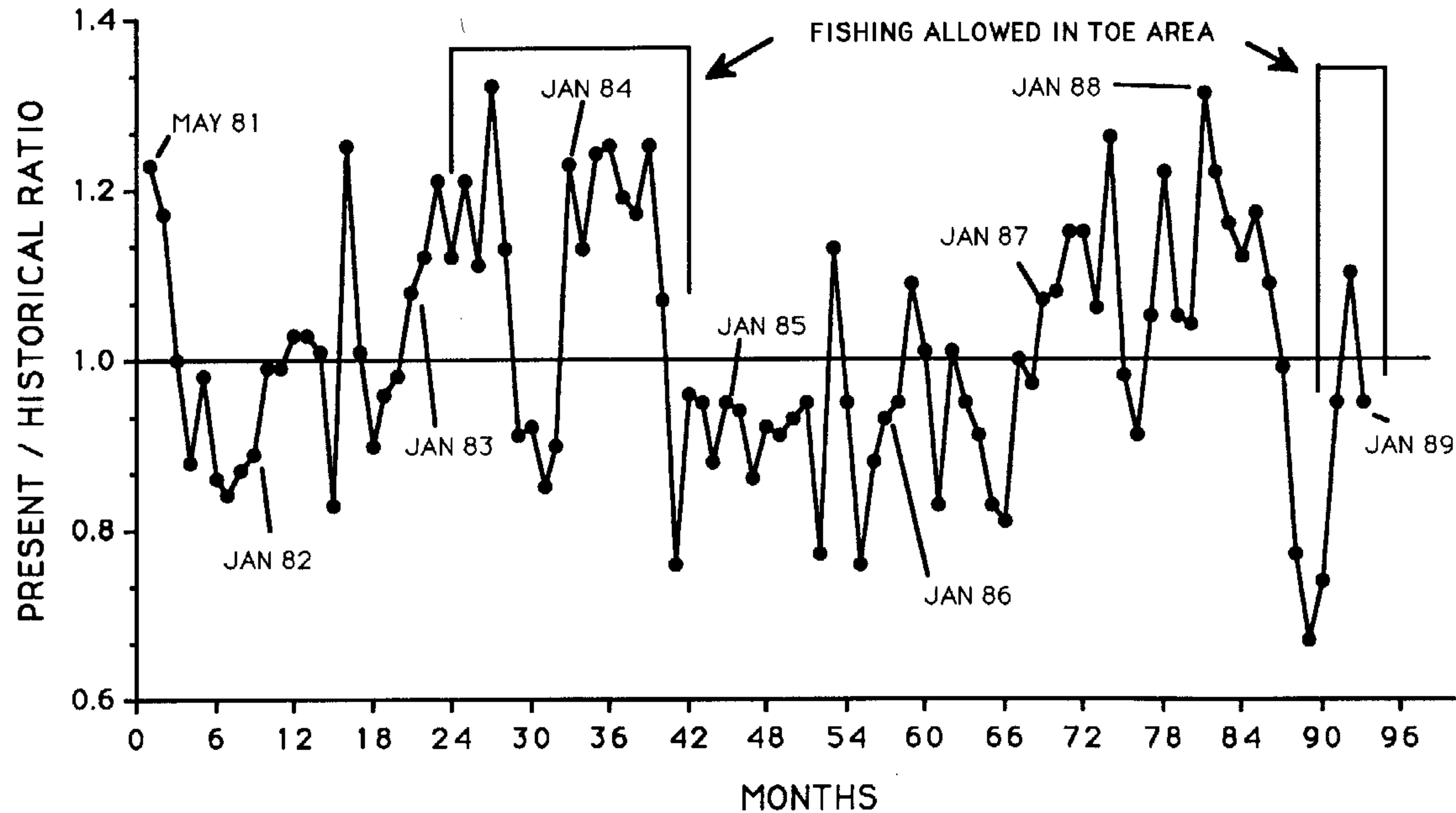


Figure 10. Ratio of monthly mean numbers of pink shrimp per pound from May 1981 through January 1989 to monthly historical mean numbers of pink shrimp per pound values (1960 through 1979).

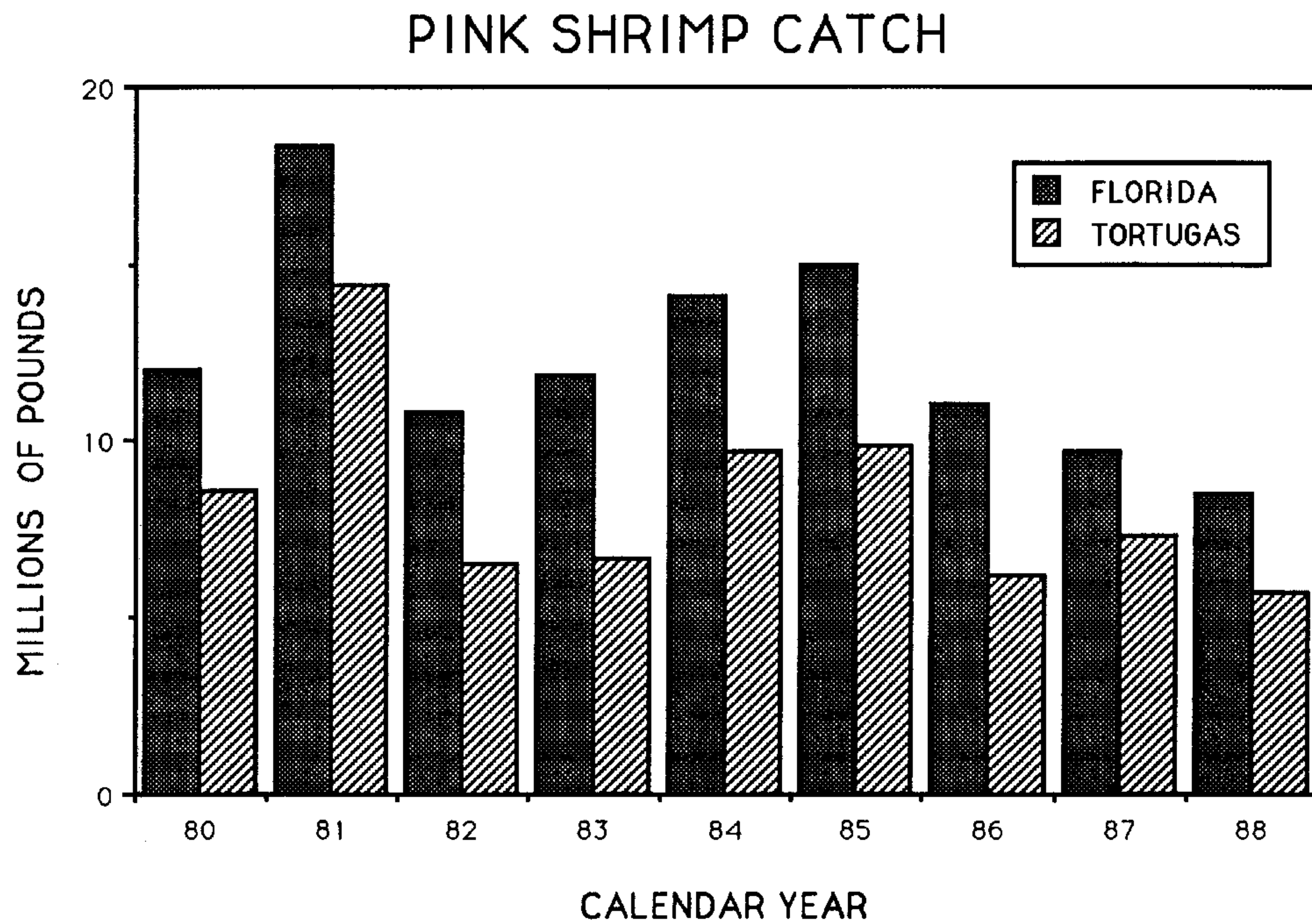


Figure 11. Comparison of annual catch from Florida (subareas 1-9) and annual catch from the Tortugas grounds (subareas 1-3).

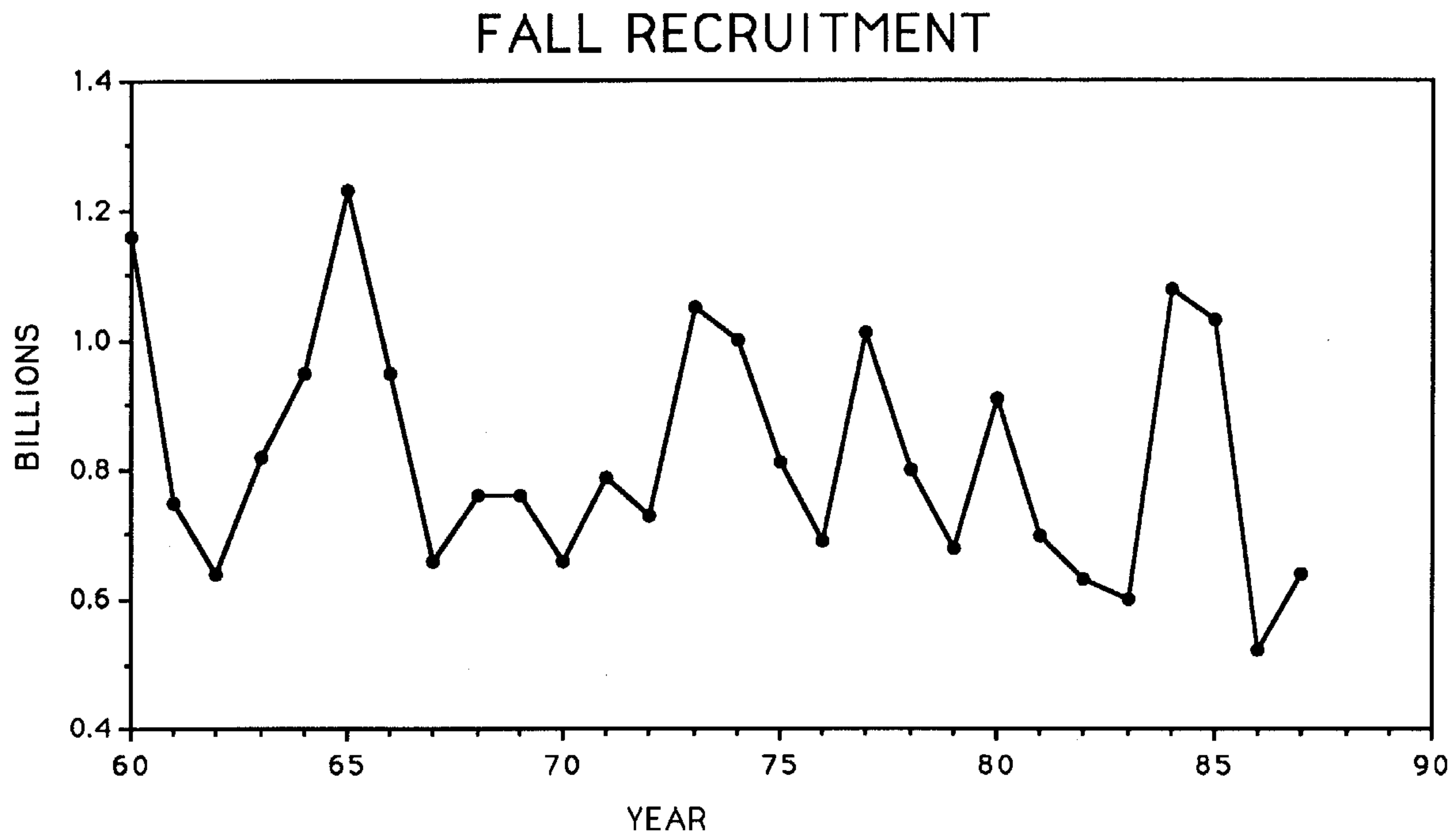


Figure 12. Estimates of fall recruitment of pink shrimp from the eastern Gulf of Mexico.